ISBN: 978-93-94687-04-2

Watershed Development for Sustainable Rural Livelihood

in

Vejalpur-Rampura Watershed, Kheda District of Gujarat

Under

National Watershed Development Program for Rainfed Agriculture

Ministry of Agriculture, Govt. of India, New Delhi

ICAR-INDIAN INSTITUTE OF SOIL AND WATER CONSERVATION (IISWC)
Research Centre, Vasad-388-306, Anand, Gujarat
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Citation

Singh, A.K., Kurothe, R.S., Rao, B.K., Pande, V.C., Singh, G., Dhakshanamoorthy, D., Jinger, D., Madhu, M., Vishwakarma, A.K., Kumar, G., Bagdi, G.L., Damor, C.N. & Kumar, A.(2023).Watershed Development for Sustainable Rural Livelihood. ICAR-IISWC, Research Centre, Vasad-388 306, Anand, Gujarat, ISBN:978-93-94687-04-2, 27p.

Published by

Director
ICAR-Indian Institute of Soil & Water Conservation(IISWC)
218, Kaulagarh Road, Dehradun-248 195, Uttrakhand, India

Edited by

Dr Bankey Bihari

Layout, Design & Production

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Year of Publication : 2023

PREFACE

Watershed development and management is a widely accepted approach used to characterize the human, aquatic, riparian and terrestrial features and their interactions within a watershed. Watershed analysis enhances our ability to assess direct, indirect and cumulative effects of our management activities in a systematic manner. The results of watershed analysis establish the context for subsequent decision making processes, including planning, project development and regulatory compliance.The participatory process is vital for success of a watershed management program. This is one of the lessons learnt over decades of failures of centrally planned watershed development projects where local people have been either coerced or paid to undertake leveling, bunding and other technical measures that external experts believed to cause watershed degradation. Thus, Participation is expected to achieve what coercion and subsidies could not, namely to make watershed development more successful and sustainable. Commitment to participatory approaches demands significant changes in our thinking about both the theory and practical aspects of sustainable watershed management. Many watershed development projects around the world have performed poorly because they failed to take into account the needs, constraints and indigenous practices being followed by the local people. Users' participation in a watershed management program sets new priorities for watershed research including how to design appropriate mechanisms for organizing stakeholders and facilitating collective action.This publication is an outcome of rigorous planning and implementation of a model watershed (National Watershed Development Program for Rainfed Agriculture) funded by Ministry of Agriculture, Govt. of India, New Delhi. Watershed approach adopted in the project area aim at treating the degraded lands with economically viable and locally acceptable technologies following participatory approaches that seek to secure active involvement of the stakeholders. The objective was to promote overall economic development and improvement of the socio-economic conditions of the resource poor and disadvantaged sections of the society inhabiting the project area.Spanning over six years (2008-2014) in first phase then two years (2020-21) in second phase, the outcomes of research and development have been closely monitored in terms of overall socio-economic status of the stakeholders by completely involving them in the decision making process.I hope this bulletin will be useful to scientists, academicians and officials of Gujarat government working under Gujarat State Watershed Management Agency (GSWMA), Gujarat Water Resource Department, Water and Land Management Institute (WALMI), Agriculture Department, Forest Department, Krishi Vigyan Kendra and other non-government agencies for implementation of watershed developmental programmes through various schemes.

(M. Madhu)
Director
ICAR -IISWC, Dehradun

Date: 26/09/2022
Place: Dehradun

ACKNOWLEDGEMENT

Authors are indebted to Dr V.N. Sharda, Former Chairman RAC, Member ASRB, and Former Director, ICAR-IISWC, Dehradun and Dr A.K. Singh, Deputy Director General (NRM), ICAR, who in fact had been the source of inspiration for conceiving, planning, getting it through and then successfully executing this important project. We are also thankful to the Director Dr. M. Madhu, ICAR-IISWC, Dehradun for providing financial assistance for publishing this bulletin.

Authors are thankful to other scientists of the center namely, Dr M.L. Gaur, Dr D.R. Sena, Dr P.R. Bhatnagar, Dr Raj Kumar, Dr Vijay kakade, Dr.O.P. Meena as well as technical officers Sh. Sh. K.D. Mayavanshi, Sh. D.G. Damor, Sh. B.C. Macwana, Sh. Ram Partap and Sh. Ankit Sukhwal who assisted in this project for executing various activities and in generation of valuable information/knowledge.Authors acknowledge the contributions made by the technical staff posted at the project headquarter, Vejalpur-Rampura watershed, during execution of the project and subsequent data collection.Authors are thankful to the Ministry of Agriculture (MoA), Government of India for funding this project under Macro Management of Agriculture (MMA), NWDPRA, New Delhi. The support and cooperation of the line departments of Gujarat state, viz.; Gujarat State Land Development Corporation, Forest Department and Agriculture Department is thankfully acknowledged.Special thanks are due to Sarpanch, farmers and executive members of Vejalpur-Rampura Watershed Jalstrav Vikas Samiti, the society formed to execute the project activities, for cooperation and support in making the project a great success.

Bulletin has been published under the supervision of the Director and Team of Scientists and Technical staff of the PME Cell at ICAR-IISWC, Dehradun. Authors are thankful to editors for editing and providing valuable proposition for improvement of the technical bulletin. Authors are also thankful to Dr M. Muruganandam, OIC, PME Cell, and his team for encouragement and processing of publication proposal. Last but not least; the authors also express thanks to Chief Administrative Officer, Sr. Finance & Account Officer and their staff at Institute HQ for support in publishing this technical bulletin. Special thanks are due to all of them for timely bringing out this bulletin.

Authors

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LIST OF ACRONYMS & EXPANSION

S. No.	Acronym	Expansion
1.	AH&VS	Animal Husbandry & Veterinary Services
2.	AET	Actual Evapo-transpiration
3.	AI	Artificial Insemination
4.	AICRPDA	All India Crops Research Project on Dry Land Agriculture
5.	AR	Annual Rainfall
6.	CPR	Common Property Resources
7.	CSWCRTI	Central Soil & Water Conservation Research & Training Institute
8.	DDG	Deputy Director General
9.	DPAP	Drought Prone Area Program
10.	EC	Electrical Conductivity
11.	EPA	Entry Point Activity
12.	FYM	Farm Yard Manure
13.	GOI	Government of India
14.	HYV	High Yielding Varieties
15.	ICAR	Indian Council of Agricultural Research
16.	IFS	Integrated Farming System
17.	IISWC	Indian Institute of Soil & Water Conservation
18.	IWDP	Integrated Watershed Development Program
19.	KVK	Krishi Vigyan Kendra
20.	LCC	Land Capability Classification
21.	M ha	Million Hectare
22.	MMA	Macro Management of Agriculture
23.	MoA	Ministry of Agriculture
24.	MSL	Mean Sea Level
25.	MAI	Moisture Adequacy Index
26.	NAP	National Agriculture Project
27.	NGO	Non-Government Organization
28.	NI	Nutrient Index
29.	NRM	Natural Resource Management
30.	NWDPRA	National Watershed Development Program for Rainfed Areas
31.	OIC	Officer-in-Charge
32.	PHC	Public Health Centre
33.	PI	Principal Investigator
34.	PIA	Project Implementing Agency
35.	PRI	Panchayat Raj Institutions
36.	PME	Prioritization, Monitoring and Evaluation
37.	QRT	Quinquennial Review Team
38.	RC	Research Centre
39.	RFD	Rock Fill Dams
40.	RRA	Rapid Rural Appraisal
41.	RVP	River Valley Project
42.	SAT	Semi-Arid Tropics
43.	SC/ST	Schedule Caste / Schedule Tribe
44.	WSM	Watershed Management
45.	SWC	Soil and Water Conservation
46.	SWOT	Strengths, Weakness, Opportunities and Threats
47.	WDF	Watershed Development Fund

1. INTRODUCTION

Water and soil resources are finite, non-renewable over the human lifetime frame, and prone to degradation through misuse and management (Lal, 2000). Scarcity of water for agricultural and domestic purpose remains a major problem and has led to low crop productivity and environmental degradation. Decline in per capita agricultural production has seriously affected food security and livelihoods of people. There is a considerable potential to bridge the yield gap between the actual and the potential yield through adoption of improved resource management technologies (Singh *et al.*, 2001 and 2008). Several studies have highlighted that appropriate rainwater management and utilization results in enhanced agricultural productivity (Samra, 1997 and 1998; Wani *et al.*, 2002 and 2003; Joshi *et al.*, 2004 and 2005). The challenge before the Indian agriculture, therefore, is to transform rainfed farming into more sustainable and productive systems through efficient use of natural resources through the integrated resource management following the concept of participatory integrated watershed management (Sikka *et al.*, 2004).

1.1. Background

The Government of India (GOI) adopted watershed management as a strategy to address the sustainable agricultural productivity in the rain-fed areas for the last three decades. Further, GOI has adopted watershed management as a national policy since 2003 (Joshi *et al.*, 2004). The prominent national programs implemented in the country are NWDPRA, IWDP, RVP/FPRs, WDPSCA, NAP and DPAP. With the launch of massive watershed development programs in the country during 1990's, all the previous programs were converged to develop different areas by adopting participatory watershed management approach.

The maximum area has been treated under IWDP (43.9 lakhs ha) followed by DPAP (25.9 lakh ha), NWDPRA (13.7 lakh ha) and other programs (13.6 lakhs ha) since inception. Similarly, the maximum expenditure has been made under NAP (Rs.708.88 crores) followed by NWDPRA (Rs.547.11 crores) (Sharda *et al.*, 2008).Vejalpur-Rampura watershed located in Kapdwanj Taluka of Kheda district of Gujarat was taken up under National Watershed Development Program for Rainfed Agriculture-Macro Management of Agriculture (NWDPRA-MMA) scheme funded by Ministry of Agriculture, Govt. of India. The watershed is located in Kapdwanj Taluka of Kheda district with latitude ranging from 22° 58' 58" N to 23° 00' 29" N and Longitude ranging from 73° 05' 51" E to 73° 08' 19" E. It is about 78 km North of Vasad in District Kheda of Gujarat State on Dakor-Kapdwanj road (Fig. 1).The project execution was carried out in the 11th five year plan period. The project envisaged overall development of the people of the watershed in a participatory mode. The major emphasis was given to the water resources development. Integrated farming system was introduced as new concept in

the watershed.This watershed program was a attempt to mitigate the adverse impacts of drought in rainfed areas. Majority of the farmers inside the watershed area got the direct or indirect benefits in terms of better soil moisture regime in their fields in one or another way. At the time of inception of farmers didn't any source of quality fodder or grass for their cattle. The pastoral and silvi-pastoral interventions in the watershed area proved to be boon, providing vast potential of dairy based interventions in the village

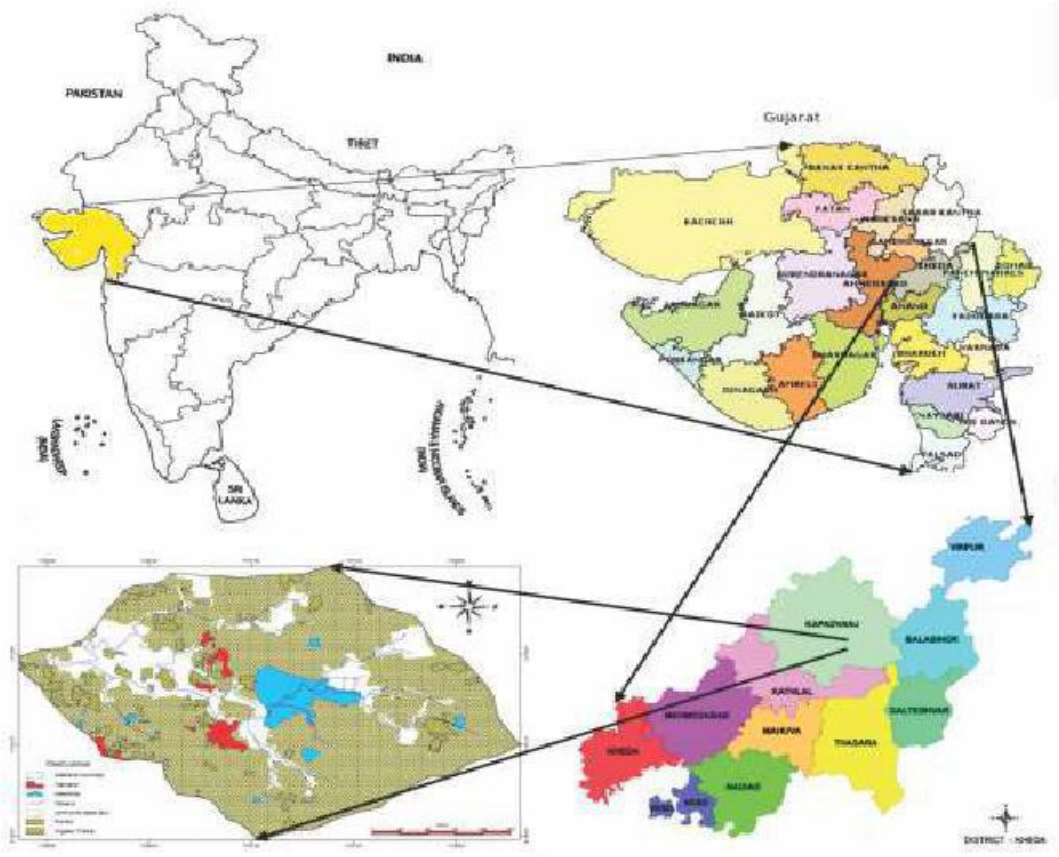

Fig.1. Location of Vejalpur-Rampura watershed in Kheda District of Gujarat

1.2. Objectives of the Study

1. To assess the impact of watershed development activities on land degradation, rainwater availability, crop productivity and livelihoods in the tribal dominated micro watershed.
2. To assess the socio-economic impact of the watershed interventions.
3. To identify the gaps/constraints in planning and implementation of activities in the watershed.

2. DESCRIPTION OF THE WATERSHED

The Vejalpur-Rampura watershed covered five villages in Kapadwanj taluka, district Kheda, Gujarat. The watershed is located at latitude ranging from 22° 58' 58" N to 23° 00' 29" N and 73° 05' 51" E to 73° 08' 19" E longitude and mean sea level of 72 to 95 m. The total area of the watershed is 775 ha. and was implemented from 2008 to 2012 (5 years). Project was sponsored by National Rainfed Area Authority (NRAA).The watershed has total population of 3484 from 1200 families with majority population engaged in farming and dairy based activities.

2.1. Climate and Agro-ecology

The Vejalpur-Rampura watershed lies in the semi-arid and rainfed area of Central Gujarat. The average annual rainfall of the area is 812 mm. Most of the annual rainfall (about 94%) is received during the rainy season (June to September) accompanied with high intensity storms. High intensity storms and cloud burst during rainy season often cause flood and heavy sedimentation in the streams. The temperature in the area goes above 40°C during summer and reaches 12°C during winter. Monthly water balance of the watershed (Fig. 2) clearly depicts that except 4 months (June to September) all other months remain dry. The monsoon rainfall occurs from mid of June to end of September (moist and humid period) during which moisture availability in excess of PET is about 1.5 mm/day. During humid period (1st July to 10th September) the excess moisture is as high as 2.8 mm/day. Rest of the season (27th September to 15th June) remains dry mostly.

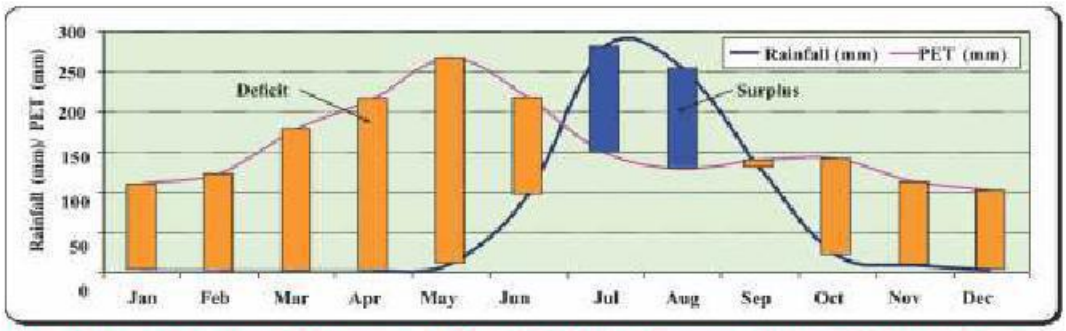

Fig. 2. Monthly water balance of the Vejalpur-Rampura watershed depicting surplus and deficit in water availability.

The aridity index is estimated to be 0.41 which evidently classify the area to semi-arid type (close proximity to the dry sub-humid climate). The wind velocity reaches from 12.8 km/h during mid-June to about 4.3 km/hr during mid-October. The evaporation from open surface area is about 678 mm/year (PET is about 1887

mm/year). An annual rainfall deficit of about 1335 mm aggravates the *Rabi* and summer crops' prospects in the watershed. An annual runoff potential of about 12% is expected from the area which comes through short duration and high intensity rainfall. The long term monthly water balance computed for Vejalpur-Rampura watershed (Table 1) shows rainfed agriculture is not a suitable option for the production system, which is the case with most of the semi-arid regions. Therefore, supplemental irrigation for rainfed production system having less water requirement is essential.

Table 1. Monthly water balance of Vejalpur-Rampura watershed

MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	TOTAL
P	2.0	0.9	1.2	1.4	10.1	96.4	281.8	254.2	130.3	21.5	9.0	2.9	**811.6**
PET	110.2	122.5	178.8	216.7	268.0	217.5	148.2	128.7	140.6	141.2	112.9	101.8	**1886.9**
AET	2.0	0.9	1.2	1.4	10.1	96.4	148.2	128.7	130.3	21.5	9.0	2.9	**552.4**
S_T	0.0	0.0	0.0	0.0	0.0	0.0	114.7	0.0	0.0	0.0	0.0	0.0	**114.7**
DS	0.0	0.0	0.0	0.0	0.0	0.0	114.7	-114.7	0.0	0.0	0.0	0.0	**0.0**
W	0.0	0.0	0.0	0.0	0.0	0.0	19.0	240.2	0.0	0.0	0.0	0.0	**259.2**
D	-108.2	-121.6	-177.6	-215.3	-257.9	-121.1	0.0	0.0	-10.4	119.6	104.0	-98.9	**1334.6**
SMI	0.018	0.007	0.007	0.006	0.038	0.443	-2.675	-1.975	-0.927	-0.152	-0.080	-0.028	**-0.018**
MAI	**0.018**	**0.007**	**0.007**	**0.006**	**0.038**	**0.443**	**1.000**	**1.000**	**0.927**	**0.152**	**0.080**	**0.028**	**0.018**

P	Rainfall (mm),	PET	Potential Evapotranspiration (mm),
AET	Actual Evapotranspiration (mm)	S_t	Plant Available Water (mm)
DS	Soil Moisture Change (mm)	W	Runoff or Surplus water (mm)
D	Deficit (mm)	SMI	Soil Moisture index(mm)
MAI	Moisture Adequacy Index (AET/PET)		

2.2. Physiography and Topography

The total area of the Vejalpur-Rampura watershed is 775 ha comprising of five villages, namely Vejalpur, Rampura, Garud, Chikhlod and Ramosodi.

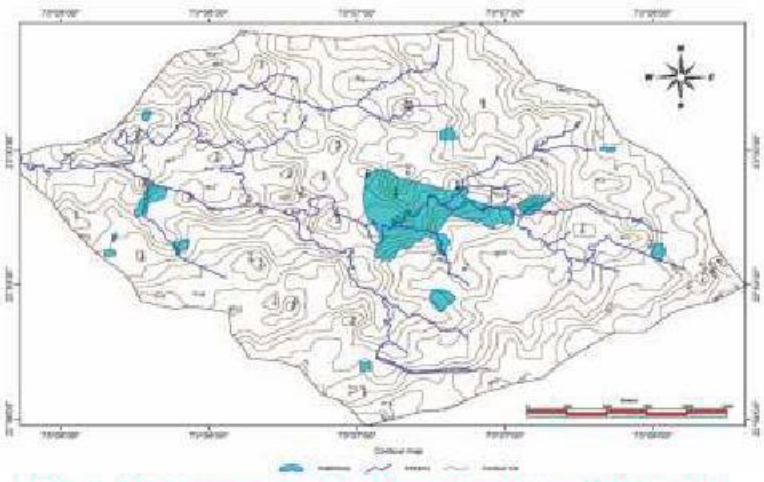

Fig. 3. Contour map of Vejalpur-Rampura watershed

The elevation ranges from 72 m to 97 m above mean sea level. The average length and width of the watershed area is 4239 m and 2745 m, respectively with a length: width ratio of 1.54: 1. The watershed area is the part of the west-coast Gujarat plain. The configuration of the area in general is gently sloping and is characterized by the problem of soil erosion varying from sheet and rill erosion in agriculture fields to gully erosion in the community wastelands (Fig. 3).

2.3. Morphology and Drainage

The watershed is compact in shape and is likely to have shorter times of water flow concentration resulting in higher runoff rates (Table 2). The average length of trunk order stream in the watershed is 7288 m (Fig. 4). The salient morphological parameters are as follows:

Table 2. Morphological characteristics of Vejalpur- Rampura watershed

S.No.	Morphological Parameters	Values
1	Perimeter	11.59 km
2	Length of main channel	7288 m
3	Maximum basin relief	25 m
4	Slope of watershed	1 to 5%
5	Drainage density	2.62 km/km^2
6	Compactness coefficient	2.32
7	Elongation ratio	0.74
8	Circularity ratio	0.73
9	Form factor	0.43
10	Relief ratio	0.74

There are three stream orders with different number of streams (Table 3). The total length is estimated to be 20336 m.

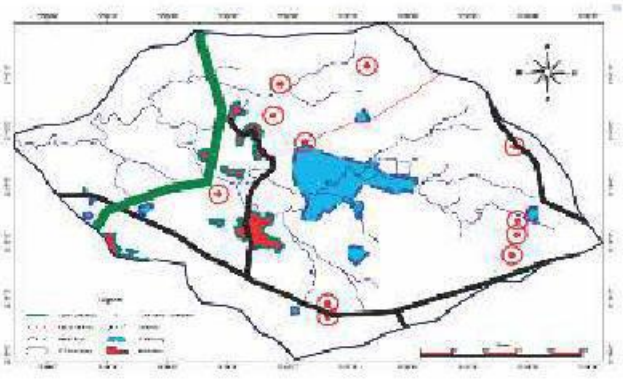

Fig. 4. Drainage map of Vejalpur-Rampura watershed

Table 3. Drainage characteristics of Vejalpur- Rampura watershed

Stream order	Stream nos.	Length (m)	Mean stream length (m)	Bifurcation ratio
1^{st}	20	10663	533	3.3
2^{nd}	06	3954	659	6.0
3^{rd}	01	5719	5719	--
Total	**27**	**20336**	**753**	

2.4. Geomorphology and Soils

The watershed is a part of west coast Gujarat alluvial plain. Soils are alluvial, very deep, and moderate to well-drained on a gently sloping land. There were hard calcareous layer in the profile at depth of 0.7 to 2 meter. Soils are fine loam to coarse loam in texture with mixed mineralogy. About half of the watershed is having sign of calcareousness. Soil temperature regime is hypothermic. Taxonomically soil belongs to Typic Ustochrepts and Fluventic Ustochrepts. Soil pH ranges from 7.4 to 8, and electrical conductivity (EC) is less than 0.5 dsm^{-1} except for the untilled salt encrusted patch where soil pH is more than 8.5 and EC > 8 dsm^{-1}. Soils are poor in fertility with surface organic carbon ranges from 0.20 to 0.32 per cent (Fig. 5).

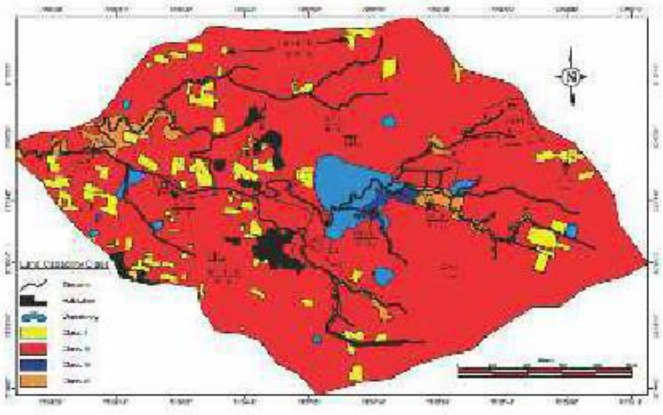

Fig. 5. Land capability classification of Vejalpur-Rampura watershed

2.5. Vegetation

The cereal, pulses, fodder, oilseed, spices and fiber crops are being grown by the farmers under rainfed as well irrigated conditions as per the availability of the water. Crops such as pearl millet, pigeon pea, green gram, moth bean, cotton, sesame, jowar, maize and castor are grown as intercropping system under rainfed condition. The total cultivated area is 597 ha and out of that 545 ha rainfed and only 51 ha area is under irrigated agriculture where paddy, castor, fennel, cumin and wheat are being grown. The pearl millet–fennel, cumin and cotton-wheat are the most common cropping systems in

the irrigated lands. Vegetable crops are not grown by the farmers of this watershed. The natural vegetation comprises tree species like *Acacia nilotica* (Desi Babool), *Tamarindus indica* (Imali), *Prosopis cineraria* (Khejri) spread along the village road, and along the streams. Species like *Azadirachta indica* (Neem), *Prosopis cineraria*, *Holoptelia integrifolia* (Kanju) etc. exist along field boundaries. There were very few fruit tree species like mango along the field boundary. Though no organized orchards were present in the watershed, homestead scattered planting of fruit trees of mango has been practiced by the farmers. No agro-forestry practices could be seen in the watershed (Fig. 6).

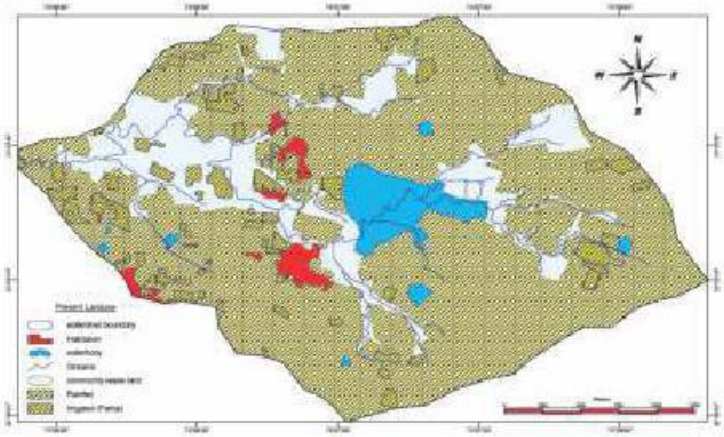

Fig. 6. Land use of Vejalpur-Rampura watershed

2.6. Demography

Out of these 5 villages in the watershed, lands of Rampura and Vejalpur village completely fall within the watershed boundary. Only few land holders of Rampura, Garud and Ramosodi are covered in the watershed boundary. The human population of Rampura, Vejalpur, Garud and Ramosodi is 1089, 690, 970 and 735 respectively. The total human population of the watershed is 3484. Majority of the watershed farmers are in the marginal category (< 1 ha) and small (1-2 ha). The small, marginal, medium and large farmers comprised of 53%, 21%, 9% and 6%, respectively. The remaining 11% farm families are landless. These small land holdings are further scattered in different patches which makes cultivation very difficult with limited options towards land utility and land treatments. Though a considerable livestock is maintained for milk production, no improved breeds were being reared in the watershed area. The total livestock population of the watershed is 1066. Milk is sold to Cooperative Dairy Society, Vejalpur-Rampura. Stakeholders did not improve the existing stock, which could only be explained in terms of fodder availability, which was, though, much higher than that available outside watershed, yet got affected by prevailing drought conditions. Therefore, milk production improvement was an important intervention proposed under the watershed program.

3. PROBLEMS & NEEDS OF THE WATERSHED

Food sufficiency, economic growth and environmental security were identified as the major issues to be addressed in the watershed area. The area has undulating topography, steep unstable slopes, excessive channel gradient and hence highly prone to soil erosion.

3.1. Problem Identification and Prioritization

Problems identified and prioritized during the and PRA in all three villages, were pooled and a list of nine problems representing the whole watershed were prepared. Problems were ranked as per their total weightage in the three villages. Lack of irrigation water was the may be problem experienced by the people followed by low production of field crops, lack of fodder availability and low animal productivity (Table 4).

Table 4. Problem identification and prioritization for Vejalpur-Rampura watershed

S.No.	Problem	Rank
1	Low production of field crops	5
2	Lack of drinking water	3
3	Lack of irrigation water	1
4	Lack of fodder availability and low annual productivity	8
5	Non-availability of fuel wood	7
6	Lack of inputs like quality seeds, fertilizer, pesticides etc.	4
7	Lack of market facility	9
8	Lack of medical, educational and transportation facilities	2
9	Medical and health care facilities for milch animals and low productivity	6

3.2. SWOT Analysis

The strength, weakness, opportunity and threat (SWOT) analysis of the Vejalpur-Rampura watershed is presented in (Table 5).

Table 5 SWOT analysis of the Vejalpur-Rampura watershed

Strengths (S)	Weakness (W)
i. Cooperative work culture in the watershed ii. Close ethical ties iii. Road at the top as well as outlet of the watershed iv. Hard working community v. Resource pool of crop genetics diversity vi. Awareness among farmers about watershed management programme vii. Well established CPR maintenance and benefit sharing system viii. Stall feeding of animals ix. Social outlook of the community towards landless	i. Poor water management ii. Resource poor farmers iii. Migration in other states iv. Low and erratic rainfall v. Fragile geology vi. Fragmented land holdings vii. Wild animals menace viii. Problem of fuel and fodder ix. Shallow soil depth and high percentage of gravel
Opportunities (O)	**Threats (T)**
i. Wide range of annual and perennial crops ii. Scope of regular employment opportunities to check out migration iii. Strengthening of existing irrigation system iv. Conducive climate for rainfed crop diversification v. Good scope for Agroforestry and dry land horticulture vi. Potential for collective action and management of CPR	i. Land de gradation and declining productivity. ii. Water scarcity for domestic and agricultural use iii. Drought prone area iv. Social conflicts owing to PRI and WSM policies and local politics. v. Community and youth move away from farming due to non-profitability vi. Weak coordination among line departments vii. Lack of expertise of implementing agency in different aspects of WSM

3.3. Natural Resource Base

Out of the total 775 ha area of Vejalpur-Rampura Watershed, an area of 597 ha is under regular cultivation, out of which 545 ha is rainfed and irrigation (only critical requirement) is available in only 50 ha. Area under grassland and wasteland is about 130 ha. Main sources of irrigation are the old defunct natural ponds which have lost their functional utility in want of effective storage and water recycling capacity.Developing integrated networks of on farm irrigation supplies from these potential water harvesting ponds has been emerged as one of the major requirement in the area. The dependency on fodder and fuel wood is largely confined to the tree and fodder crops grown along field bunds and the fodder crops grown in individual fields. There is no forest area in the watershed.The village *Gauchar* land (common land for villagers) is devoid of trees. Animals depend on grazing on these lands. However, the carrying capacity of these *Gauchar* lands is low as these are not managed by the village panchayat.

4. COMMUNITY ORGANIZATION, ENTRY POINT ACTIVITIES AND CAPACITY BUILDING PROGRAMS

Several activities were carried out for the rapport building with the farmers and villagers before starting the natural resource management works in the Watershed. The details of some of the entry point activities carried out for community organization and capacity building are discussed below.

4.1. Entry Point Activities

Under entry point activities, four solar street light systems, two at Ramosodi and two at Rrampura were set up. Three hand pumps (Photo. 1) were installed at Vejalpur and Rampura. Two TV sets with Dish connection were installed at Vejalpur and Rampura panchayats. Similarly, two chaff cutter, one each at Vejalpur and Rampura were distributed (Table 6).

Table 6. Details of entry point activities in the watershed

Component activities	Achievement	
	Physical (nos.)	No. of families benefited
Solar street light system	4	37
Hand pump	3	31
TV set with dish	2	5
Chaff-cutter	2	7

Photo. 1. Hand pump installation and TV with dish connection

4.2. Community Organization

A society named as 'Vejalpur-Rampura Watershed Society' was formed with farmers of these villages as members. After formation of the society a Watershed executive committee was formed consisting of 13 members through election among local farmers (Photo. 2). Subsequently, 4 User Groups and 4 Self Help Groups were also formed. The users groups included crop development, horticulture and vegetable development, forest and pasture development and soil & water conservation.The self-help groups included Grah Udyog Vikas, tailoring & embroidery and poultry

development. Four papad making groups having 10 women members were constituted from 4 villages of watershed. There were 4 papad making units purchased and training given to women. About 16 ladies were trained in garment making for 4 months duration. Ten sewing machines were distributed among women of watershed, for tailoring work to earn their livelihood. One woman is earning Rs.100-150 per day by sewing clothes. Ten farmers were distributed 25 chicks each with iron cage for poultry rearing in the watershed. Farmers are earning Rs.120 per bird in a month by selling eggs.

Photo. 2. Sensitization of watershed stakeholders for committee formation

4.3. Capacity Building Program

Capacities of the watershed committee and watershed executive members were built through regular training programs on various aspects. A training programme on "Common Guidelines for Watershed Development" was organized at ICAR-IISWC, RC, Vasad for farmers of Vejalpur-Rampura watershed to orient them about watershed guidelines (Photo.3). Similarly, exposure visits of watershed farmers were also conducted to expose them to community work execution.

Photo. 3. Capacity building of watershed executive members

5. WATERSHED DEVELOPMENT WORKS (ARABLE LAND, NON-ARABLE LAND, DRAINAGE LINE TREATMENT, LIVELIHOOD SUPPORT SYSTEMS & PRODUCTION & MICRO ENTERPRISES)

The development works included land leveling in 25 ha, field and peripheral bund in 100 ha, 30 gully plugs, nearly 20 nos. of check dam, 6 water harvesting ponds, 6 nos. of pond deepening, staggered contour trenching in 22 ha and continuous trenching in 10 ha, 04 groundwater recharge filters, plantation in 10 ha, 100 nos. of crop demonstrations.

5.1. Field and Peripheral Bund

Field bunds of 0.6 m^2 cross section in 6000 m length in 100 ha were constructed. Due to bunding (Photo. 4) crop yields were increased up to 20%. Gully & rill formations were observed in the fields where field bunds was not constructed and gully was extended up to 1 m.

Photo. 4. Peripheral bund & field bund

5.2. Staggered and Continuous Contour Trenches

Staggered contour trenches of sizes 1.2 × 0.3 × 0.3 m, 2 × 0.5 × 0.5 m were made in 22 ha (Photo. 5). Continuous contour trenches of 0.3 × 0.3 m were made in 10 ha. Plantation and grass sodding was done in these areas. In these trenches water holding was observed up to 3 days. During drought year also higher survival, better growth of plants and fodder was recorded in plantation with trenching.

Photo. 5. Forest plantation supported with staggered contour trench in community land

During 2009-10, about 640 plants of *Acacia nilotica* and *Azadirachta indica* were planted in 1.6 ha area in Rampura community land under afforestation activities of watershed program. The area was protected with the bio-fence of *Euphorbia spp.* to check biotic interference. Similarly, 600 plants of *Acacia nilotica*, and *Azadirachta indica* were also planted along with *Cenchrus setigerus* (Dhaman grass) in 1ha area in Ramosadi community land under silvi-pasture activity. Survival of trees was ranged from 11 to 74% as a result of moisture retained in trenches. Survival of *Acacia nilotica* was found better as compared to *Azadirachta indica* in both the villages (Photo. 6 & Photo. 7).

Photo. 6. Staggered contour trenches

Photo. 7. Continuous contour trenches

5.3. Gully Plugs

Under drainage line treatment structures, earthen gully plug structures, masonry check dams were constructed. Thirty gully plug structures were constructed (Photo. 8). In these structures, silt deposition was recorded up to 25 cum. and water storage capacity varies from 20 - 800 cum.

Photo. 8. Gully plug structures in drainage line

5.4. Check Dams

Eight check dams were constructed for effectively treating the upper part of the catchment and create storage so as to augment ground water recharge for the wells adjacent to it (Photo.9). Two check dams (water harvesting cum drainage line treatment type) have been constructed on the upper part of the catchment encompassing two major gullies that contributes the largest pond (Vejalpur pond) in the watershed.

Photo. 9. Check dams constructed for drainage line treatment

5.5. Water Resource Development Structures

Water resource development structures included embankment ponds, dugout farm ponds, water harvesting check dams and recharge filters (Photo. 10). Under water resource development in arable lands, 6 dugout ponds of 500 cu. m. capacity were constructed in farmers' fields. Daily depth of water and water utilization of these ponds were recorded. It is observed that water was stored up to December. Fish culture was also introduced in these ponds. Seepage losses were observed to be 0.030 and 0.0042 m3/m2/day in unlined and lined ponds respectively. Three embankment ponds, 10 check dams and four recharge filters were constructed. Embankment ponds and check dams were able to store the large quantity of runoff water and increased the water yield of the surrounding wells. The number of irrigations increased and accordingly yield increase was also recorded up to 50%.

Photo. 10. Water resource development works in Vejalpur-Rampura watershed

5.6. Pond Renovation

Renovation and deepening activities in the existing ponds were carried out at four places of which Vejalpur main pond accounts for a major chunk. The work aimed at renovating a major bund near Vejalpur outlet which was washed away before and submerging the village Rampura (Photo. 11).

Photo. 11. Renovation of dugout pond

5.7. Groundwater Recharge Filters

Four recharge filters (low-cost) were constructed in farmer's field to increase the groundwater recharge through open wells in the farmers' field (Photo. 12).

Photo. 12. Recharge filter in arable land

5.8. Fodder Grass in Community Land

The 10 ha community land (4 ha at Ramosodi and 6 ha at Vejalpur) was ploughed with MB plough and seeded with grass seed of *Cenchrus spp.* during monsoon season (Photo. 13).

Photo. 13. Seeding pasture grass in Ramosodi community land in the watershed

5.9. Improved Crop Cultivation

Improved crop cultivation practices in terms of balanced fertilization, improved varieties and timely availability of inputs were the key factor for increasing production and profitability of pearl millet, cotton, castor and vegetable crops on 63 ha of land. Timely availability of seeds, fertilizers, and otherinputs was ensured inputs to

the farmers through crop demonstrations (Photo. 14). These package and practices resulted in improved production and livelihood of the farming community.

Photo. 14. Introduction of improved cropping systems

5.10. Vermi-Compost Production

Four vermicomposting units have been established in farmer's field (Photo. 15) and farmers were trained in vermi-compost production technology. Production of compost has been initiated by farmers and yield of 500 kg/pit has been recorded.

Photo. 15. Vermi-compost unit installed at Ramosodi village

6. MONITORING & IMPACT EVALUATION

6.1. Arable Land Treatment Technologies & Its Impact

a. Field bund and peripheral bund

Gully and rill formations were observed in the fields where peripheral bunds and field bunds were lacking and gully was extended up to 1m every year, hence under arable land treatment, field bunds of 0.54 m^2 cross section in 1650 m length (26 ha) and peripheral bunds of 0.7 m^2 cross section in 2334 m length (45 ha) were constructed which increased crop yields by 5 to 8% (Table 7).

Table 7. Yield increase due to field and peripheral bund

Crop	Average % increase in yield
Bajra	5.08
Maize	5.58
Rainfed paddy	7.85

b. Dugout ponds

Daily depth of water and water utilization from these ponds revealed that water was stored up to first week of February. These ponds provided one to two life-saving irrigations. Yield increase reported was up to 42 % (Table 8). Seepage losses were observed to be 0.032 and 0.0045 $m^3/m^2/day$ in unlined and lined ponds respectively. Seepage loss reduction was reported by 86%.

Table 8. Impact of dugout ponds

Item	Pond 1	Pond 2
Capacity (cum)	450	450
Crop	Rainfed paddy	Sorghum (fodder)
No of life saving irrigations	2	1
Area irrigated (ha)	0.3	0.25
% yield increased	42	33

c. Groundwater recharge filter

The groundwater recharge filters constructed in the farmer's field were used to divert the excess runoff from the crop field for artificial recharge through open well. The recharge filters also increases the water availability in the well for a longer period.

The average water table was increased by 0.84 m in the watershed and the farmers were able to irrigate the *Rabi* crops. An additional 16 ha area was brought under assured irrigation which was kept fallow due to non-availability of sufficient irrigation water during summer season.

6.2. Non-Arable Land Treatment Technologies & Their Impact

a. Staggered and continuous contour trenches

Plantation and grass sodding was done supported by staggered and continuous contour trenches in community areas. In these trenches water holding was recorded up to 5 days. Better growth and survival was recorded in the plantations supported by trenches (Table 9).

Table 9. Plants survival under silvi-pasture due to moisture conserved in trenches in community land

Location	Species	Number plants	Average plants survival (%)
Ramosoli village community land	Acacia nilotica	200	74
	Azadirachta indica	200	11
	Azadirachta indica	200	67
Nan-rampura village community land	Acacia nilotica	240	38
	Azadirachta indica	400	20

b. Gully plug structures

The observations on gully plug structures revealed good silt retention and water storage behind the structures (Table 10).

Table 10. Silt deposition and water storage behind gully plugs

Gully plug no.	Silt deposition (cum)	Water storage (cum)
Gully plug 1	17.37	75
Gully plug 2	15.48	165
Gully plug 3	39.97	790
Gully plug 4	28.29	189
Gully plug 5	32.34	202
Gully plug 6	14.64	61.2

c. Check dams

Two check dams were constructed in two major gullies that pass through the Nana Rampur village and have a pronounced effect in submerging larger tract downstream. Beside these two check dams provide huge storage behind in augmenting groundwater recharge in natural way and also scope for surface irrigation through mechanical lifting.

Two more check dams were constructed at the outlet of two ponds namely Panipurotha pond and Bhehat pond, expected to assure huge storage on the upper part of catchment and can ensure multiple usage of water. One check dam was constructed in Thoribas assisting our plantation activities resulting in better soil moisture regime. One check dam is located at the extreme outlet which was simultaneously utilized for gauging the watershed and ensuring an in-channel water storage in about 1.32 km.

6.3. Production System & Micro Enterprises

a. Crop demonstration for balanced fertilization & HYV

Demonstrations for balanced fertilization (4R Stewardship, right time, right dose right method and right place), high yielding varieties (replacement of old varieties) were executed in cotton and pearl millet crop under farmers field (Photo. 16 & 17).The area covered under demonstration was 7.25 and 11.2 ha for cotton and pearl millet, respectively. The demonstrations increased the yield of cotton and pearl millet by 74% and 30%, respectively, as compared to the farmer practices (Table 11).

Photo. 16. Profuse growth of Bt-Cotton (Vikram-5) under demonstration

Photo. 17. Excellent growth of Pearl Millet (Pioneer Hybrid-86 M-52) under demonstration

Table 11: Balanced nutrition in different crops

Particular	Crops									
	Bajra		Bt cotton		Castor	Fennel			Cumin	
	Fp	Demo.	Fp	Demo.	Fp	Demo.	Fp	Demo.	Fp	Demo.
N	110	120	120	120	110	120	100	120	120	120
P_2o_5	46	70	60	60	46	70	46	60	60	60
K_2o	0	60	0	60	0	60	0	40	0	40
Zn-	0	10	-	-	0	10	-	-	-	-
Variety-	Hy. Bajra	Pioneer hybrid – 86 m-52	Bt cotton	Bt cotton vikram-5	Gch-4	Gch-4	Local	Local	Local	Gujarat-4
Yield (q/ha)	18.4	32.14	15.00	19.54	13.00	16.50	10.00	13.50	5.0	7.75
Wue (kg/mm)	3.34	5.84	1.76	2.29	3.34	5.84	1.56	2.11	1.25	1.93
Returns (₹/ha)	-	-	62825	81841	53534	67985	79302	107058	52645	81600

b. Crop demonstration for conservation tillage

Better performance of crop (Photo. 18) was observed as a result of introduction of high yielding variety (GCH-7) and conservation tillage. Even during scanty rainfall (424 mm) period farmers were able to harvest good crop successfully. Under demonstrations higher castor yield (16.5 q/ha) was realized as compared to farmers yield (13.0 q/ha). The conservation tillage and improved variety increased the crop yield, water use efficiency and returns by 26.9%, 74.8 and 30%, respectively (Table 11).

Photo. 18. Crop performance under demonstration for conservation tillage and HYV

c. Demonstration for spice crop development

Under spices development 10.5 ha. area was covered with fennel and cumin crop (Photo. 19 and 26). Farmers realized higher returns (Table 11) with improved practices as compared to farmers' existing practices. The demonstration increased the yield and water use efficiency of fennel and cumin by 35% and 55%, respectively.

Photo 19. Fennel crop

Photo. 20. Cumin crop

d. Demonstration for fodder development

Under fodder development 5.75 ha. area was covered under fodder sorghum. Under rainfed conditions higher fodder yield (15 q/ha) was observed under demonstration as compared to farmers practice (12.15 q/ha). The yield increment of 23.4% has been recorded from demonstrations over farmers practice. This demonstration was executed for improving the milk production of the milch animal and eventually income of the farming community of the watershed area.

6.4. Livelihood Activities and Income Generation

a. Sewing and papad making activities

Vocational training was imparted to the women farmer of the watershed area. Under the training women were trained for sewing fabric and materials together. In this training, around sixty women beneficiaries were trained. There were, ten sewing machines including accessories and practice materials, distributed to the women beneficiaries (Photo. 21).Two grinding machines for *Papad* making unit were procured and handed over to beneficiaries after training (Photo. 21). Forty *Papad* making hand tools have also been procured and distributed to the women beneficiaries.

Photo. 21. Livelihood activities, tailoring and flour mill introduced in the watershed

b. Poultry bird rearing for supplementing income

Poultry rearing is the fastest income earning enterprise. Therefore, to improve the livelihood and living of the farming community in the watershed area poultry enterprise was introduced for that, 10 poultry bird units with iron cage were distributed to poor and marginal farmers (Photo. 22).The average investment of Rs. 1953/- per household was incurred on iron cage and poultry birds. This enterprise generated an income of Rs 2030/household/year (Table 12).


Photo. 22. Poultry bird rearing for supplementing the income

Table 12. Income generation from poultry bird rearing activity

S. No.	Description	
1.	No of enterprises	10
2.	Av. Investment (₹ / house hold)	1953
3.	Income generated (₹ / house hold / annum)	2030

6.5. Training and Exposure Visits

No. of watershed executive committee meetings with local farmers were organized. Training cum exposure visit to Junagarh Agricultural University, Junagadh, Gujarat was conducted for 31 watershed farmers. Farmers Day (Kisan diwas) was also organized to motivate the farmers for their contribution in the economy of the country and their role in nutritional security of the burgeoning population of India (Photo. 23).


Photo. 23. Kisan diwas in watershed

7. LESSONS LEARNT

Sheet erosion caused due to high velocity runoff and ground water depletion are major degradation processes threatening sustainability of production potential of rainfed ecosystem of the region. The erratic rainfall pattern associated with hot and extended summers limits the option for cultivation and productive utilization of uncultivable lands. Due to lack of education and scanty resources in rainfed areas the rural communities are poorly equipped to face the challenge of unfriendly environmental conditions. The starvation deaths reported from rainfed regions during last decade due to drought are indicative of grievous situations.

The conservation measures applied in the Vejalpur-Rampura watershed were highly ameliorative cum remunerative in semi-arid tract of Central Gujarat Region. Rehabilitation of eroded land with increased soil moisture was the most apparent and immediate benefits experienced. With improved cropping practices these ameliorative effect can be enhanced to quickly recover the cost of conservation measures.

However, under severe drought situation as experienced during year 2010 and 2011, conservation measures and improved cropping practices were found inadequate to sustain even minimum level of productivity required to support livelihood of human and cattle population of Vejalpur-Rampura watershed. However, strengthening existing water harvesting structures and developing additional village ponds effectively reduced drought affect on livelihoods.

It is clear from the developmental work in the Vejalpur-Rampura watershed that irrespective of male or female farmers, improved level of socio-economic status, knowledge, risk taking ability and positive attitude were positively and significantly correlated with the farmer's participation in planning phase. Thus, right from beginning (rapport building phase), care should be taken, to involve those who are low on various independent variable, to get the variety of ideas and experiences from every strata of the village society, a prime requisite for perfect participatory planning, development and finally management of natural resources.

The implementation of watershed development project in Vejalpur-Rampura watershed has surfaced some of the concerns and constraints need to be focused upon by research and developmental agencies.

8. CONSTRAINTS & RECOMMENDATIONS

- One of the major constraints experienced in the project implementation was excessive biotic interference, which was a major limitations restricting the successful establishment of vegetation in community pasture land as well as in the private waste land. Open grazing habit of large animal population, largely owned by poor farmers, was difficult to regulate.

- There is good scope of enhancing drought resistance potential and sustainability of production system through promoting appropriate silvi-pastoral system on community land and planting fodder or timber tree species on field bunds. Concept of social fencing needs to be strengthened to regulate grazing habits of animals. Also behavior of poor farmers and their animals needs to be focused to develop alternate viable strategies.

- There is need to identify and refine remunerative alternate land uses and management options which can ensure minimum productivity under drought situation and improve potential to maximize production in normal rainfall year.

- Synergies and complementariness of joint management of arable and non-arable lands following farming systems approach need to be explored on watershed basis. Community conflicts, equity and lack of institutionalized management mechanism are the emerging issues and need attention.

9. GAPS IDENTIFIED & SUGGESTIONS FOR POLICY PLANNERS

- In most of the watershed management projects emphasis is on improving agricultural productivity. Alternate livelihood options are not experimented including animal husbandry and allied agricultural activities like apiary, pisciculture etc. Strengthening of local cottage industries needs major attention.

- During planning phase participation of local stakeholders needs to be increased. Tools like PRA/ RRA need to be meticulously utilized for this purpose.

- There is need for sensitizing farmers on the issues related to soil and water conservation.

- The principal of reward for protector of soil and water is relevant in rainfed areas as options for ground water recharge lack incentives for upstream stakeholders.

- The watershed management programs shall be spread over 7-8 years so that maintenance of previous year's works can be insured. Currently despite provisions of post project management funds there is little maintenance of CPR's once the projects are over.

- Monitoring of watershed management programs shall be taken up right from the beginning especially before implementation of treatments starts.

- For development of wastelands as fuel/fodder reserves, there is need to sensitize local population towards benefits of stall feeding and use of top feed and fodder species especially in semi-arid region of Central Gujarat.

10. CONSTRAINTS ANALYSIS & SUGGESTIONS FOR IMPROVING THE WATERSHED MANAGEMENT PROJECTS IN RAINFED REGIONS OF GUJARAT

The ICAR-Indian Institute of Soil and Water Conservation, Research Centre, Vasad has developed two model watersheds and the scientists of the Research Centre have also worked in other watershed development programs for several years. Based on the experiences of scientists of the center about IWMP projects developed by the center and exposure to the watershed management projects conducted by NGO's and state government agencies in the Central Gujarat, the experts are of the view that watershed management projects in the semi-arid region pose major constraints for planning and field execution.

The relatively better success of the watershed management projects developed and executed by the centers of ICAR-IISWC, Dehradun as compared to other agencies is largely due to the following broad reasons:

- There is definite superiority in the watershed development team of the ICAR-IISWC, Dehradun and its centers as compared to the WDT of other agencies. Experienced scientists contribute at the planning and implementation phase at ICAR-IISWC while most of the times the WDT of other agencies lacks services of properly trained manpower.
- Many times it has been experienced that state government officers trained at ICAR-IISWC, Dehradun and its centers are engaged in other jobs after returning to their department and the job of watershed management projects are assigned to people lacking concepts in the watershed management.
- Most of the times the WDT of other agencies are overloaded as they are assigned to develop more than one watershed at one time. At times officers for watershed management team are also assigned tasks related to other government schemes more related to watershed management. This leads to rushing against time during the important phases of planning and implementation.
- Especially in case of state government agencies the approach in watershed development is target orientated rather than result orientated. This leads to development of DPR's based on pre-decided format and leaves little room for out of the box thinking to incorporate innovative solution for location specific problems.

Nevertheless, unlike the watersheds in the plains the semi-arid regions needs more cost intensive mechanical measures and implementation of vegetative measures is also more costly due to topographic and physical constraints. Thus priorities in the ravine watersheds are different than the watersheds located in plain areas.

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12. APPENDIX

Financial and Physical Targets and Achievements

S. No.	Component/Activities	2009-10				2010-11			2011-12				
		Target		Achievement		Target		Achievement	Target	Achievement			
		Phy.(ha)	Financial	Phy. (ha)	Financial	Phy.(ha)	Financial	Phy.(ha)	Financial	Phy. (ha)	Financial	Phy.(ha)	Financial
1	Management Component												
	Transport/DA		100000		32081		100000		128127		100000		57925
	Skilled Persons		90000		47054		180000		93238		180000		237097
	Stationary		10000		3970		20000		16183		20000		30000
	Contingencies		20000		5636		20000		16521		20000		29957
	Monitoring		23000				18000				23000		
	Evaluation												
	Sub Total		233000		88741		318000	0	254069	0	313000	0	354979
2	Entry point activities												
	Solar street light system	4			58000			2	58000		0	2	58000
	Hand pump	2			78157			2	82644		0	1	57982
	Chaff-cutter	2			39000			2	39000		0		
	TV set with dish in panchayat office	2			28000			2	28000		0		
	Drinking water tank in school*	1			0				0		0		
	Platform construction at temple in Nana-Rampura*	1			0				0		0		
	Sub Total				203157		0	0	207644	0	0	0	115982
	Institution & capacity building (Training)												
	Training capacity building	10										6	151129
	Exposure visits.	10										2	50988
	Sub Total		150000		127660		120000	0	108323	0	45000	0	202117
3	Watershed works phase												
	Arable Land- Agri-horticulture										0	6	45852
	Agro-forestry development										0	2	5875
	Field bunds										0	50	188767
	Soil Conservation Measures												
	Peripheral bunds							20	60514			25	88912

	Dugout ponds (small)							12 (1200 cum)	228733			4 (400 cum)	41124
	Land smoothening /levelling							6.63	79560			13.37	84614
	Check dams with recharge filter			19.7	128758			15	88345				
	Non-arable land												
	Pasture development with bio-fencing											12	146635
	Silvi-pasture development											1	38756
	Afforestation											1.6	24037
	Bamboo / forest tree plantation											5.75	77350
	Nursery raising / Kisan nursery										0	0.01	4370
	Staggered trenches							15	162480			5	78340
	Continuous contour trenches											10	60000
	Pond deepening / capacity enhancement							3.53	21000			30	203195
	Recharge filter and check dam							21.4 (2 nos.)	126257				
	Drainage LineTreatments												
	Details of Activities												
	i) Embankment type ponds											90.83 (2 nos.)	403632
	ii) Small earthen gullyplug structures							19.4 (650cum)	168162			25.58 (1500 cum)	193608
	iii) Water harvesting check dams							70.4 (6nos)	501184			55 (1 no)	306481
	Sub Total							89.8	669346			171.41	903721
	Livelihood supportsystem												
	Fish culture							0.1	2780			0.3	56138
	Poultry enterprise							10 units	48000			5 units	33250
	Goat rearing (5 animals unit per family)												
	Sub Total								50780				89388
	Production and Micro Enterprises												
	10 Sewing machine			4 nos.	20800			6 nos.	33000				
	Replacement of old varieties							7.25	40308			14	96319
	Balanced fertilization & method of placement							11.75	52345			14	87421

	Vegetative development							0.5	3900			0.5	4500
	Spices development							10.5	66398				
	Fodder development							5.75	23151			5.25	27038
	Crop of diversification							2	18935				1000
	Floriculture development								0				
	Conservation tillage							2	23409			3	20000
	Drip / micro irrigationdevelopment (Horti & Agri.)								0				
	Vermi compositing unit							4 nos.	76944				
	Evaporation based cool chamber												
	Bee keeping												
	Accessories forcommon use												
	Papad making unit							2 nos.	24000			2 nos.	10000
	Roof water harvestingsystem												
	Others (Soil analysis)								29472				
	Sub Total								391862				246278
4	Consolidation phase -Details of activities												
	Watershed plus activities												
	Project completion report												
	Post project satelliteimageries / Documentation												592
	Sub Total				0				0				592
	Grand Total				**23829 9**				**234059 1**				**3000884**

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2022